Source-to-Health Outcomes / Multi-pollutant

Long Term Goal 2

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Office of Research and Development

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NRC PM Research Priorities

1. Outdoor Measures vs. Personal Exposure

6. Dosimetry & Fate of Deposited PM

2. Exposure of Susceptible Populations to PM Components

7. Combined Effects of PM and Gaseous Pollutants

3. Characterization of Sources

PM Research Needed to Minimize Health Risks

8. Susceptible Subpopulations

9. Mechanisms of Injury

4. Air Quality Model Development & Testing

5. Assessment of Hazardous PM Components

10. Analysis & Measurements

11. Technical Support– Atmospheric Measurements and Methods

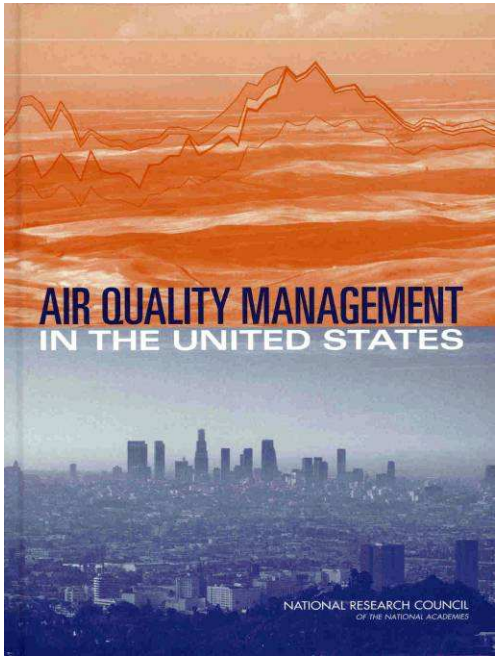
12. Source to Health Outcome

"From a Particulate Matter Research Program to a Multi-pollutant Research Program: This shift in focus should acknowledge that real-world exposures involve complex mixtures of hundreds of air contaminants of several physical-chemical classes."

NRC Report on *Air Quality Management in the United States*, 2004

- **The report suggests that the process could be improved by transitioning from the current pollutant-by-pollutant approach to an integrated, multi-pollutant AQ management strategy based on reducing risk and oriented towards achieving results.**

- **"Take an Integrated Multi-pollutant Approach to mitigate the most significant risks."**



2004

Develop Multi-pollutant Research Approach

- Multi-pollutant research strategy
  - Integrated across ORD and OAR
- OAR initiated a multi-pollutant risk reduction strategy focused on Detroit, MI
  - ORD's Clean Air research supports this effort
- Work closely with OAR to further develop research strategy
  - Joint OAR-ORD workshops on risk attribution to MP atmosphere – March 2008 and Sept. 2009 (others to follow)
  - Research relevant to ORD clients – inform policy
- Multi-city/multi-pollutant studies
  - Integrated epidemiological and toxicological studies to assess health outcomes with components of air pollution

Creating a Common Understanding of "Multi-pollutant"

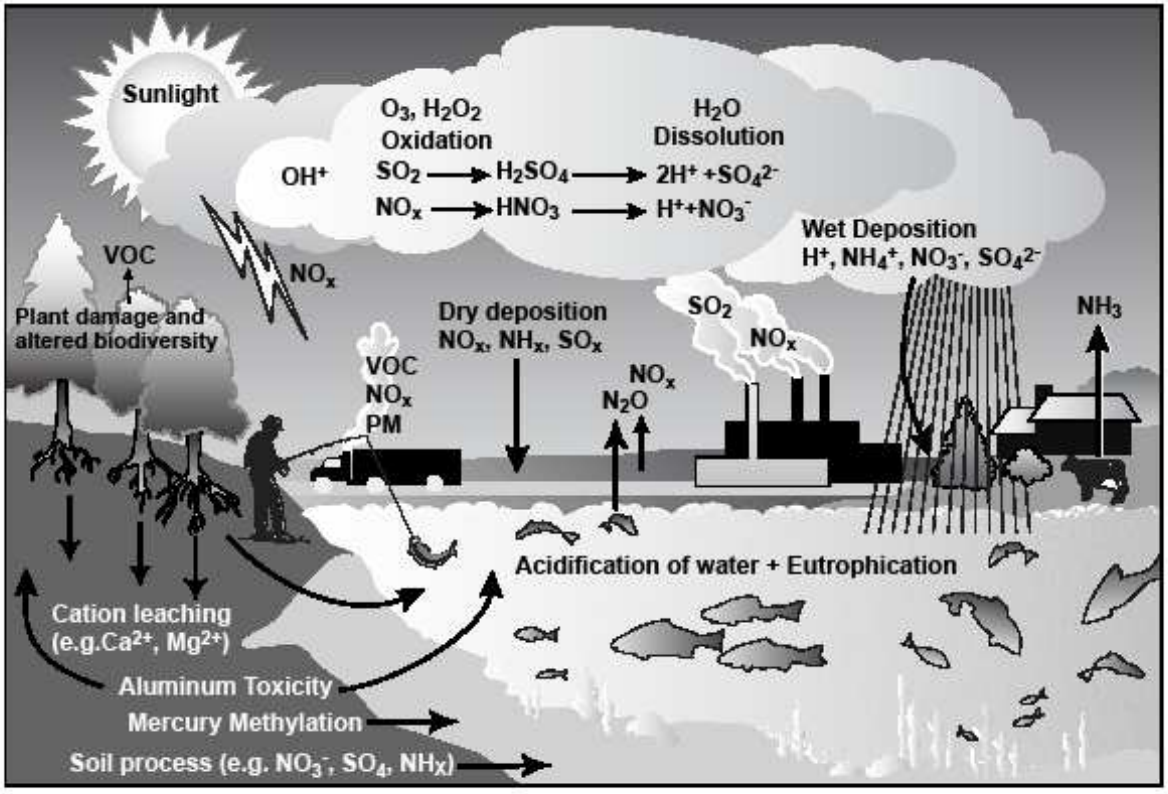
- Multi-pollutant has become a buzzword for changing our air quality management paradigm
- But there are many ways to define multipollutant:
  - Sources of emissions (e.g. utilities emit NO_x, SO_2, $PM_{2.5}$)
  - Controls (e.g. reduced fuel sulfur affects both SO_2 and NO_x emissions from diesel trucks)
  - Atmospheric processes (e.g. NO_x is a precursor to both O_3 and $PM_{2.5}$)
  - Receptors (e.g. humans breath in a mixture of O_3, PM, and other pollutants)
  - Effects (e.g. O_3 and PM both contribute to respiratory hospital admissions)

Creating a Common Understanding of "Multi-pollutant"

- And there are many ways to define multi-pollutant management:
  - Achievement of single pollutant goals recognizing multi-pollutant sources and atmosphere
  - Achievement of single pollutant goals recognizing co-benefits for other pollutants
  - Combinations of strategies to efficiently address multiple air quality goals
  - Strategies to address multi-pollutant risks, recognizing synergies and tradeoffs in controls, air quality, and effects

What about multi-pollutant standards?

- EPA is exploring a multi-pollutant secondary standard for NO_x and SO_x, accounting for the joint atmospheric processes and ecological effects associated with these pollutants (Rea poster LTG1-38)



Long Term Goal 2

LTG 2 - **Reduce uncertainties in linking health and environmental outcomes to air pollution sources.**

- Develop a multi-pollutant approach to research
- Identify specific source-to-health linkages, using near-roadway as the prototype
- Assess health and environmental improvements due to past regulatory actions (i.e. accountability)
- Look to the future: air quality–climate interactions

Prototype Source to Health-Outcome Approach: Near Roadway Studies

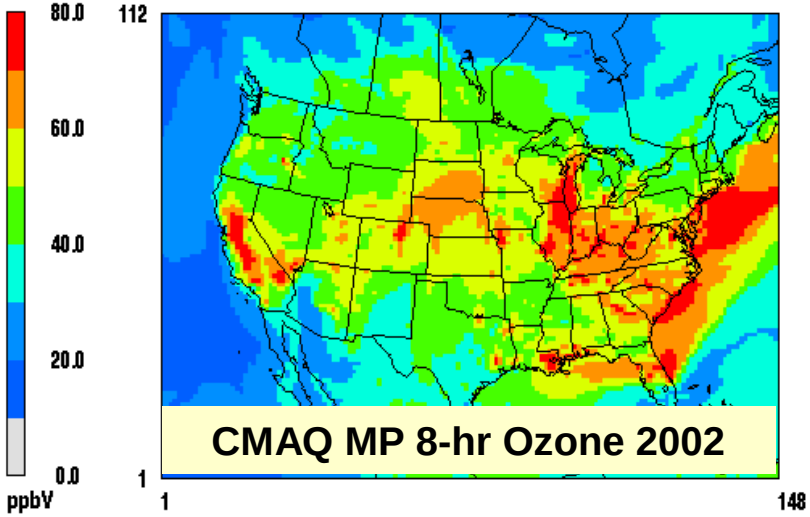
Pressing Program and Regional Need with PM and Air Toxic Implications

- Asthma
- Birth defects
- CV effects
- Cancer

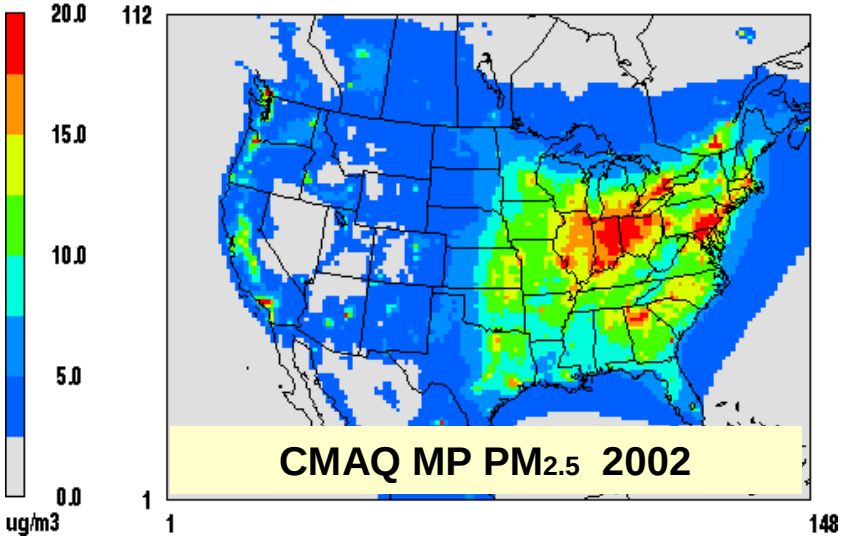
- **What do we really know about exposure?***
- **Health Implications?**
- **Interventions exist – value?**

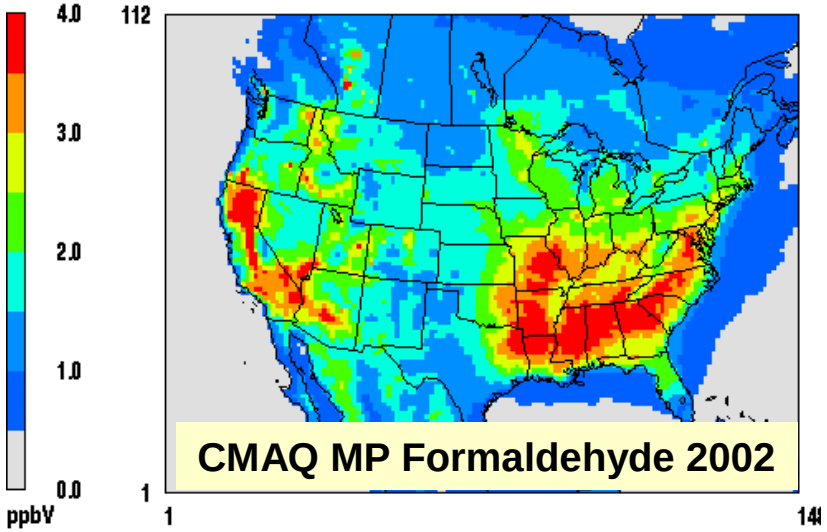
****Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects* – Health Effects Institute (May, 2009)**

Expanding the Application of AQ Models

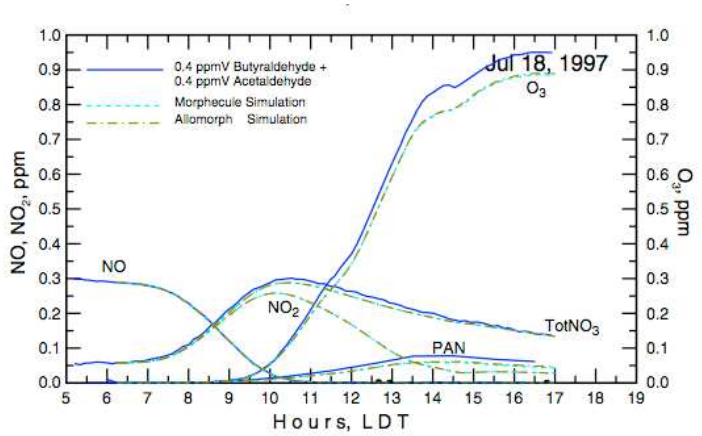


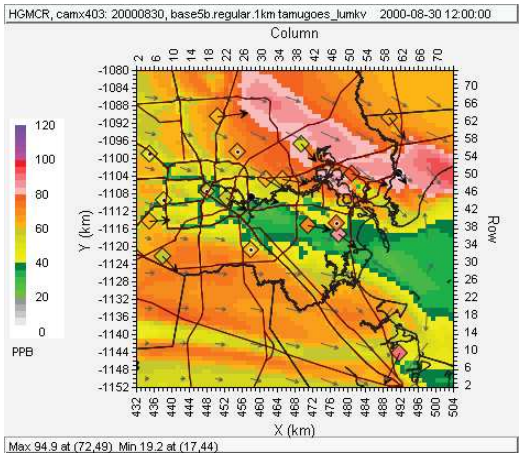
- Development of MP Models
- Regional to Local
- Explore refined exposure estimates through the use of source-apportionment and AQ models linked to population data





Simulated Atmosphere Research





- Goal is to create artificial atmospheres that are representative of real world MP mixtures.
- Health effects can be associated with different mixes.
- Various precursors, including those associated with climate change, can be used.

EPA-ORD is purchasing a smaller, simpler version of this MP chamber

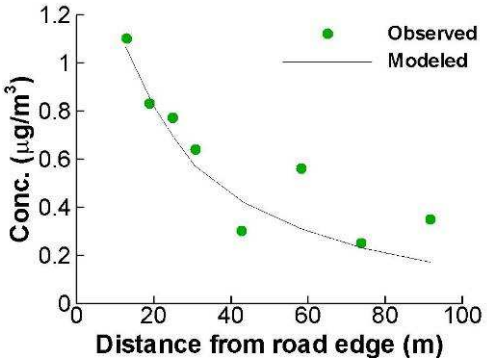
Source-to-Health Outcomes / Multi-pollutant Session

Session is organized around 4 themes:

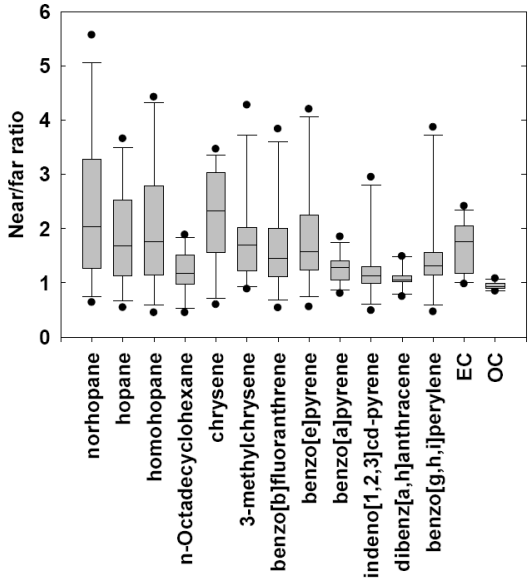
- Linking MP sources and health effects
- Atmospheric transport and transformation
- Influence of airshed on MP air quality and health effects
- Assessing and managing MP exposures and health effects

Linking MP Sources and Effects
Near-Road

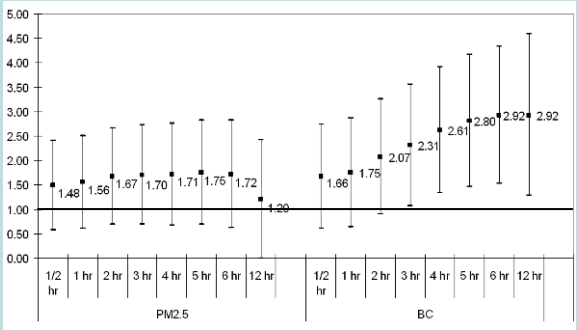
Spatial Gradients – Air Toxics



Spatial Gradients – PM Components



T-wave Alternans



Cardiovascular effects due to BC

Childhood Asthma

Traffic metric	OR (95% CI) Current asthma (*n* = 88/724)	Bronchitis (*n* = 87/745)
Distance to freeway/highway		
≤ 75 m	3.80 (1.20–11.71)	2.81 (0.94–8.39)
> 75 to ≤ 150 m	1.87 (0.71–4.90)	1.82 (0.75–4.40)
> 150 to ≤ 300 m	1.25 (0.50–3.11)	2.00 (0.93–4.29)
> 300 m	1.00	1.00

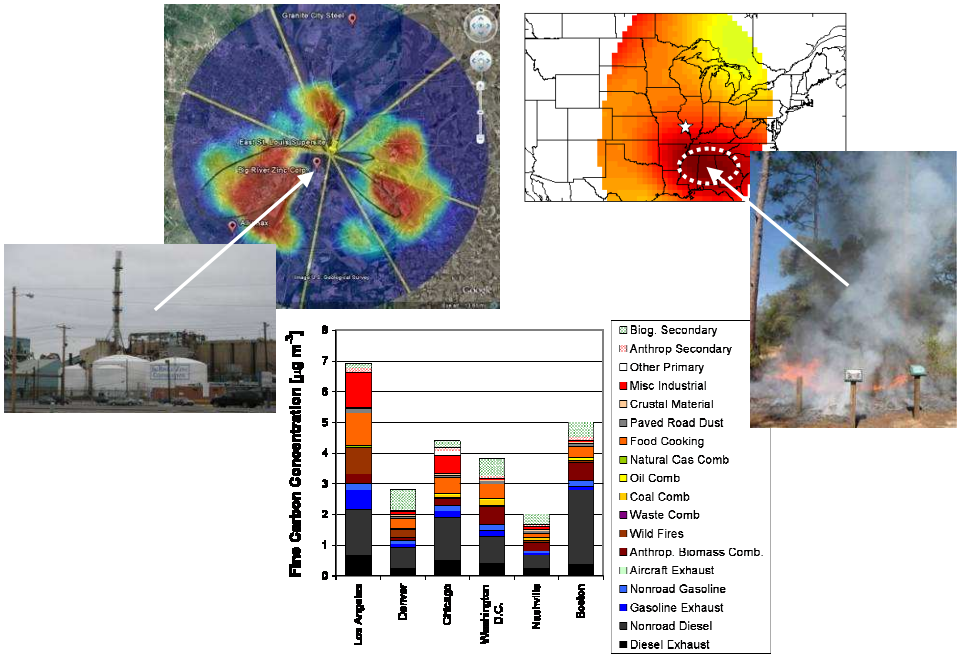
Proximity to traffic related to current childhood asthma

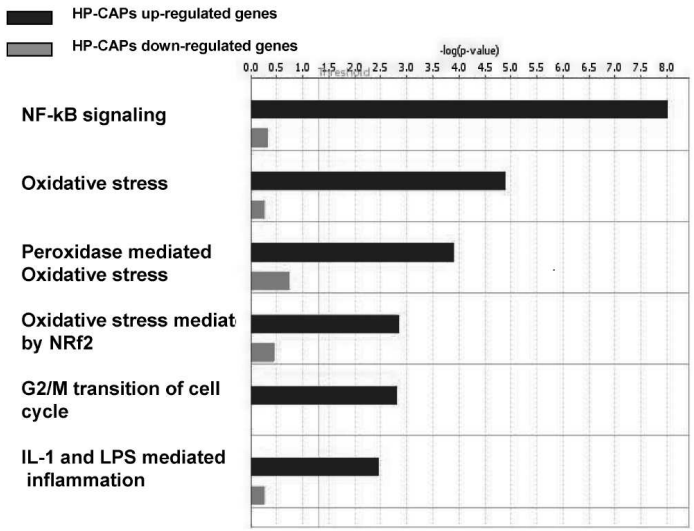
Baldauf Poster (LTG2-01)

Neas Poster (LTG2-02)

Linking MP Sources and Effects
Stationary / Area Sources

Integrating methods, measurements and models to quantify the impact of local and regional sources on air quality and health effects in differing airsheds across the U.S.





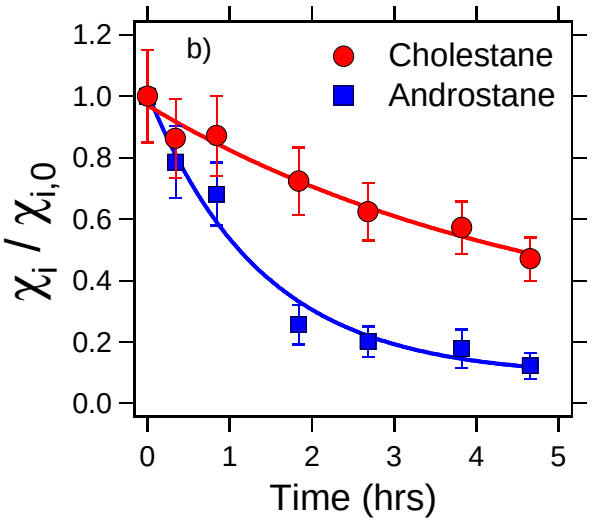
Bioassay with epithelial cells – NF-κβ activation associated with Ni + V (oil combustion) in NY air

Burke Poster (LTG2-03)

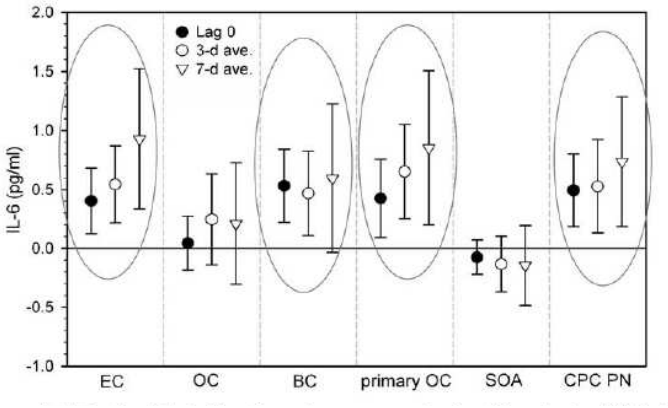
Madden Poster (LTG2-04)

Atmospheric Transport and Transformation

Effect of Atmospheric Processing

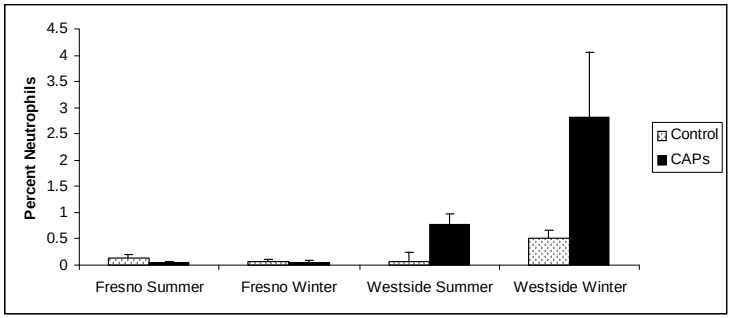


Primary molecular markers of OC decay with time in the presence of oxidants.
Primary OC and its markers are lost from the particle phase over time.



Primary PM components such as EC and OC appear to correlate with health endpoints more strongly than SOA

But…

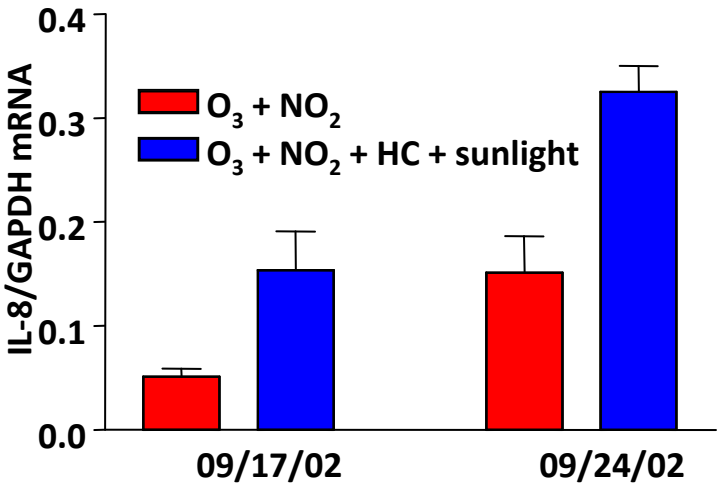


Concentrated ambient particles (CAPs) studies suggest that aged primary particles induce greater amounts of inflammation than fresh primary particles.

Kleeman Poster (LTG2-05)

Atmospheric Transport and Transformation
Simulated Atmospheres

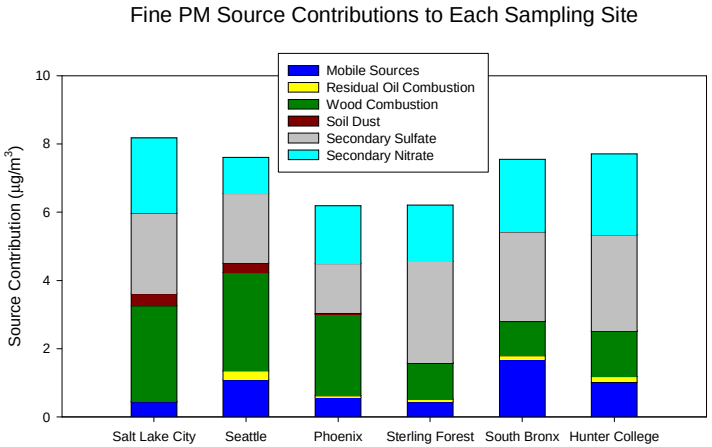
Atmospheric chambers have been widely used to study chemical reaction mechanisms. Research is now underway to use these chambers to generate MP atmospheres for health studies.



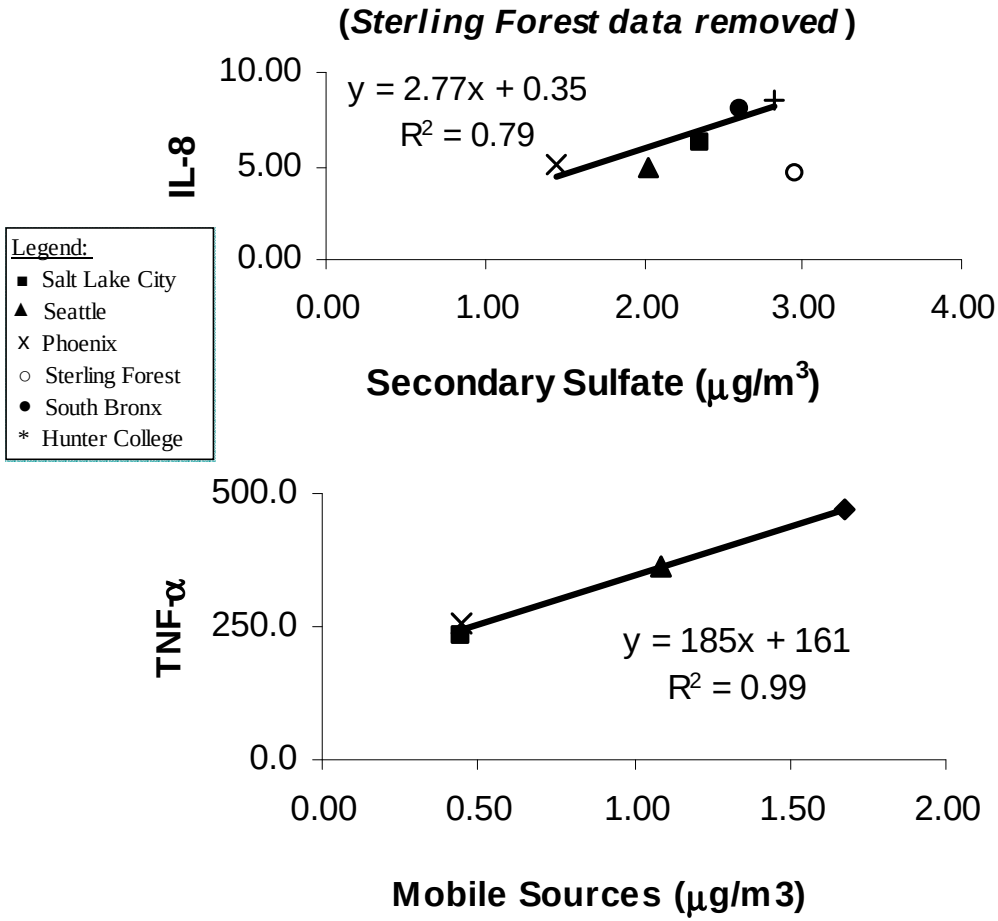
Greater amounts of IL-8, an inflammatory marker, were induced in lung epithelial cells when exposed to atmospheres of urban mixtures after photochemical aging involving O_3. Secondary products, especially carbonyl compounds, were significant contributors to cell death and inflammation.

Koutrakis Poster (LTG2-06)

Atmospheric Transport and Transformation
Establishing Source-Receptor Relationships



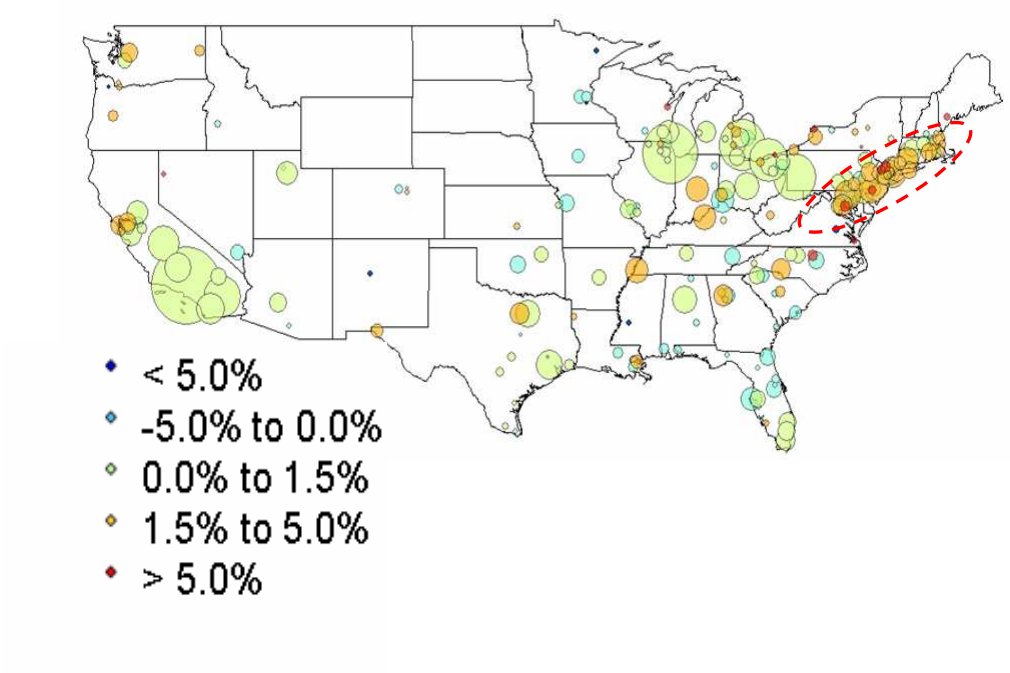
Source-receptor models have been used to successfully resolve source impacts on air quality and health effects.



Duvall Poster (LTG2-07)

Influence of Airshed on MP Air Quality and Health Effects
Regional Differences

Higher CV related hospital admissions in Eastern U.S. associated with $PM_{2.5}$, EC, V and Ni

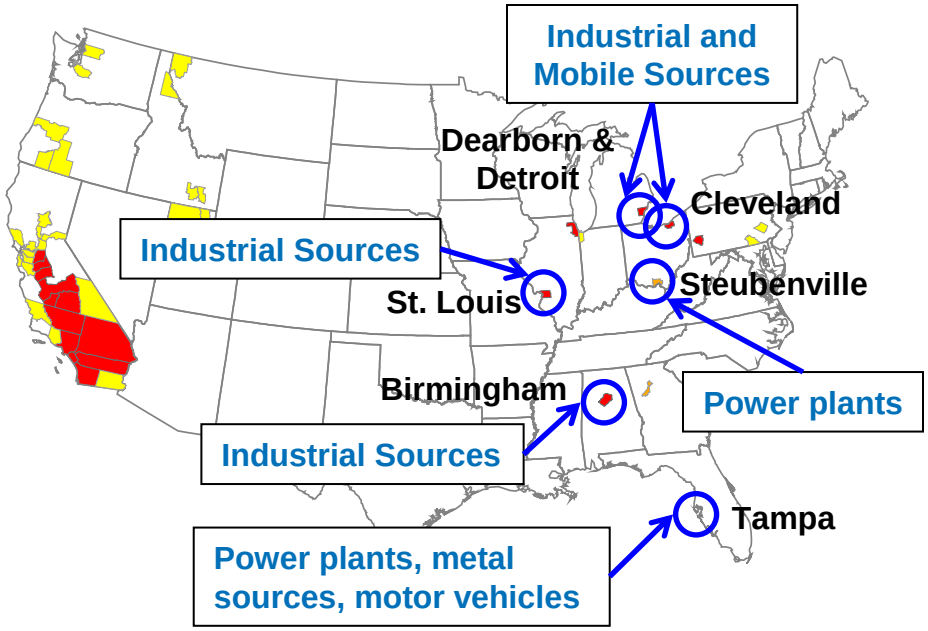


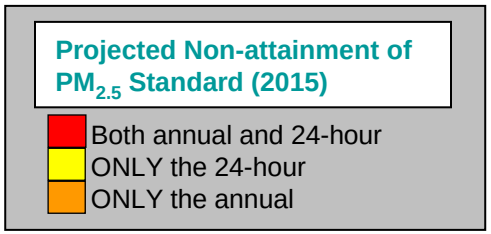
Spatial heterogeneity in health effects may be due to source/pollutant mixture, atmospheric processing or both. Further research is needed to better understand important processes.

Dominici Poster (LTG2-08)

Influence of Airshed on MP Air Quality and Health Effects

Assessing Impacts from Multiple Sources





Development and application of high- and low-time resolution sampling and analytical methods along with an ensemble of modeling analyses to differentiate the myriad of local and regional sources. Integrated source and health studies to assess source-to-health outcome.

Norris Poster (LTG2-09)

Influence of Airshed on MP Air Quality and Health Effects

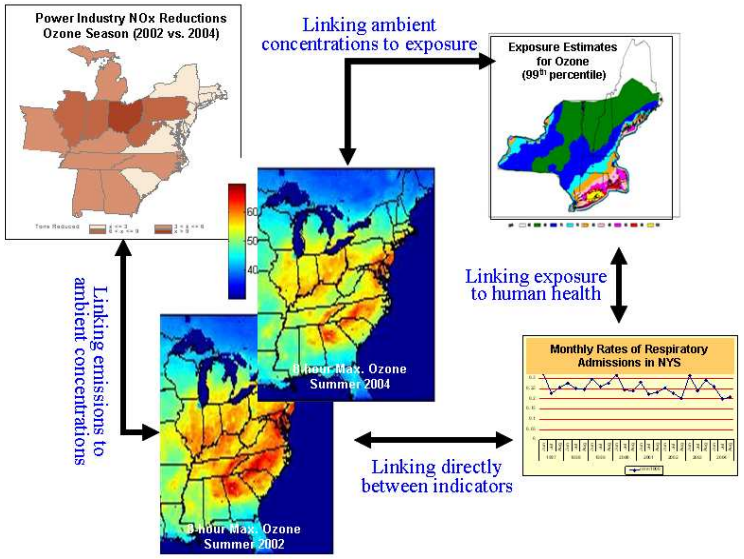
Effectiveness of Regulations - Accountability

Accountability research is a leveraged effort with ORD and HEI

Long-term reductions in PM2.5 (1980s and 1990s) associated with increased life expectancy (> 0.5 year)

Detecting a measurable signal has been difficult in some short-term interventions (Atlanta Olympics); preliminary data from Beijing Olympics show changes in biomarkers of oxidative stress related to reduced air pollution

Develop indicators across source-to-outcome continuum to assess changes due to regulatory actions

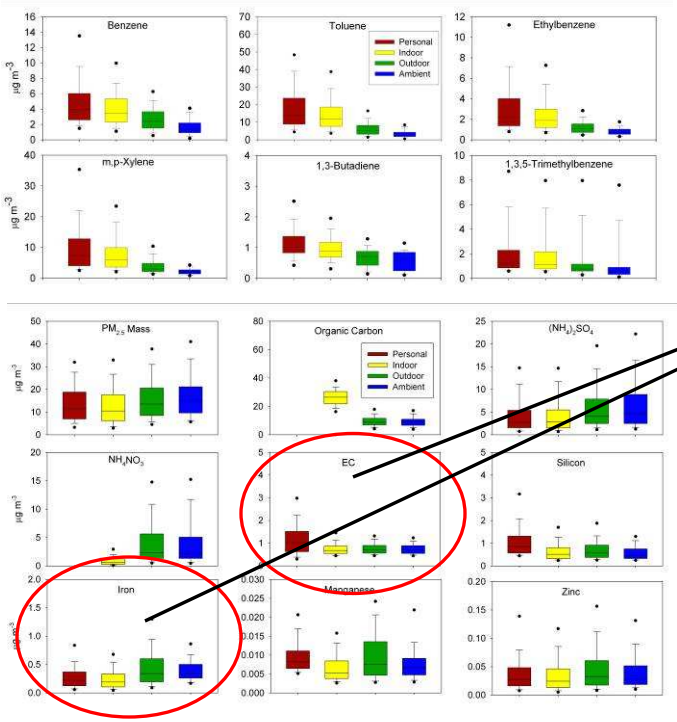


Garcia Poster (LTG2-10)

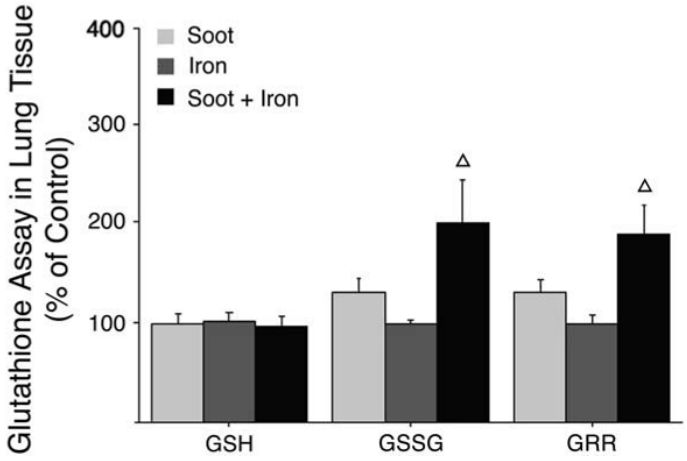
Assessing and Managing Multi-pollutant Exposures and Health Effects

Evaluating Combined Effects

People are simultaneously exposed to multiple pollutants from a variety of sources and microenvironments



These multi-pollutant exposures may result in synergistic effects.



Toxicology results show synergistic effects between iron and soot particles.

Williams Poster (LTG2-12)

Pinkerton Poster (LTG2-11)

Assessing and Managing Multi-pollutant Exposures and Health Effects

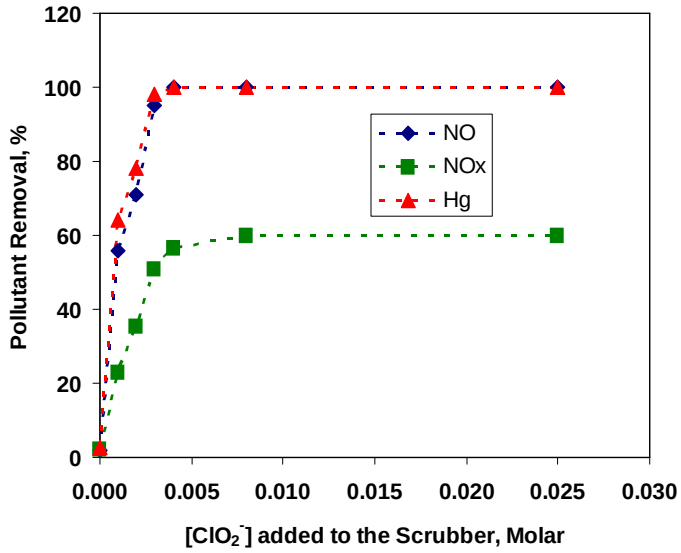
Relative Toxicity of Sources

Cause of death	Particle type	p-Value	Percent increase for IQR increase (95% CI)
CVD	BC	0.13	1.5 (–0.4 to 3.4)
	Sulfate	0.72	–0.2 (–1.5 to 1.0)
Stroke	BC	0.06	4.4 (–0.2 to 9.3)
	Sulfate	0.39	2.0 (–2.4 to 6.1)
Respiratory	BC	0.04	3.7 (0.1 to 7.4)
	Sulfate	0.20	2.1 (–1.1 to 5.3)
Diabetes	BC	0.13	5.7 (–1.7 to 13.7)
	Sulfate	0.36	2.9 (–3.1 to 9.5)

Most health studies use single pollutants as source markers and have found associations with inferred sources.

Future research is directed at high-time resolution source-oriented sampling for health analyses.

Wexler Poster (LTG2-13)



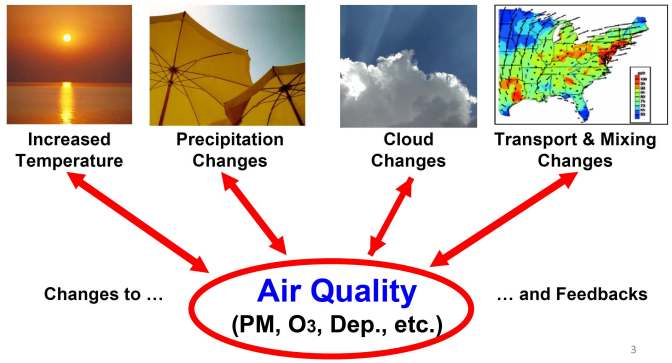
These source-oriented studies provide insight into which pollutants to target for emissions reductions. Shown here is an amended wet-scrubber technology to remove multiple pollutants. Initial bench tests show promise.

Hutson Poster (LTG2-14)

Program Priorities Related to This Research

A major issue for OAR is risk attribution to specific pollutants within the context of MP atmospheres.

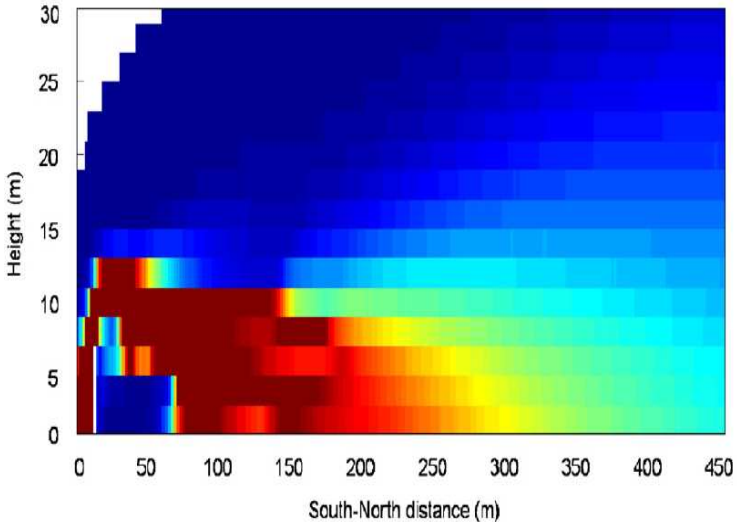
Model interactions between air quality and climate to estimate the public health impacts of climate mitigation strategies.



Jenkins Poster (LTG2-15)

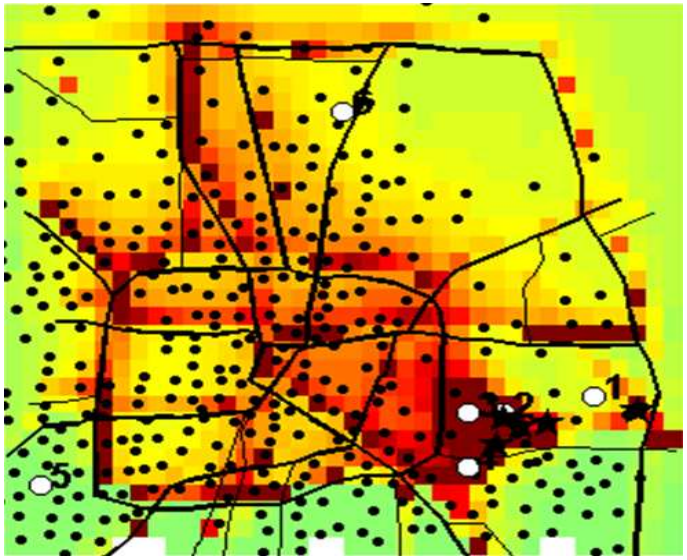
How is this Research Being Used?

Modeled pollutant dispersion near a roadway with a noise barrier



ORD's multiple research approaches are helping to deliver tools that could help mitigate air pollution from roads from the beginning of the roadway design process.

Modeled benzene concentrations in Houston



Elevated concentrations near roadways overlap with areas of high population density

Cook Poster (LTG2-16)

Future Directions

- Clean Air Research Centers RFA
  - Build on success of PM Centers
  - Address key uncertainties and processes
  - Relevant to understand health effects from exposures to MP atmospheres
- Climate–Air Quality interactions/feedback